Challenges in High Rise Construction

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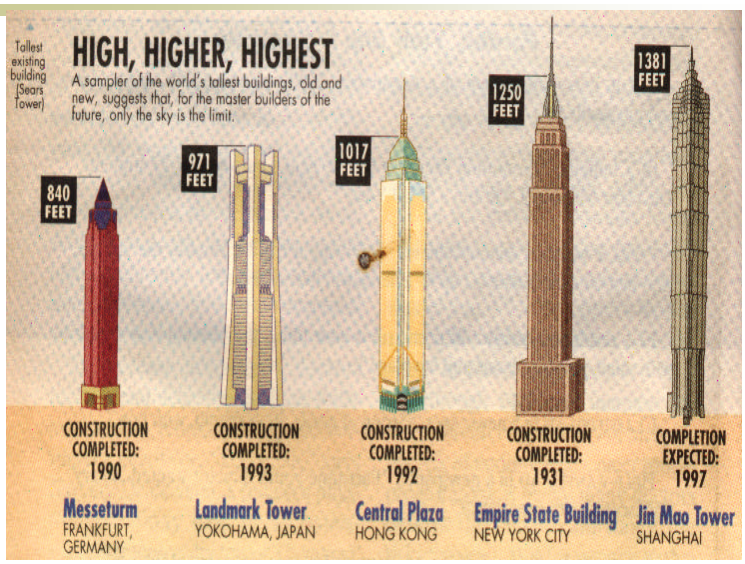
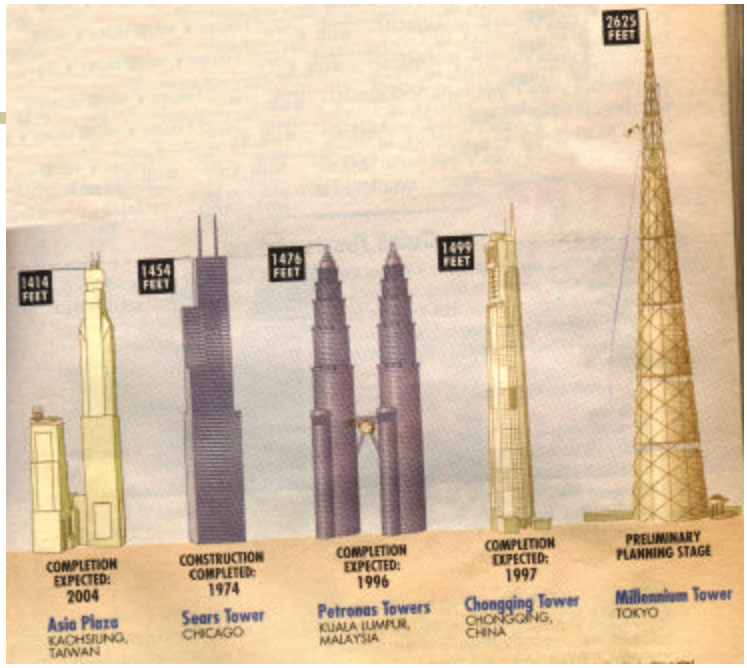
RACE TO THE CLOUDS





World's Top 10 Buildings

1 Petronas Tower Kuala Lumpur1483
2 Sears Tower Chicago1450
3 Jin Mao Tower Shanghai 1380
4 Citic Plaza Guangzhou 1283
5 Shun Hing Square Shenzhen 1260
6 Empire State Building New York 1250
7 Central Plaza Hong Kong 1227
8 Bank Of China Hong Kong 1209
9 The Center Hong Kong 1148
10 T & C Tower Kaohsiung Taiwan 1140
11 Aon Center Chicago 1136
12 John Hancock Center Chicago 1127
13 Burj al Arab Hotel Dubai UAE 1053
14 Baiyoke Tower II Bangkok Thailand 1050

Taipei

Sears

Petronas

Empire State

Sky Tower　　Citic Plaza

Manhattan Skyline and Central Park

City Skyline, Chicago

Golden Triangle section of KL, where Petronas Towers dominate the skyline.

CHALLENGES IN HIGH RISE CONSTRUCTION

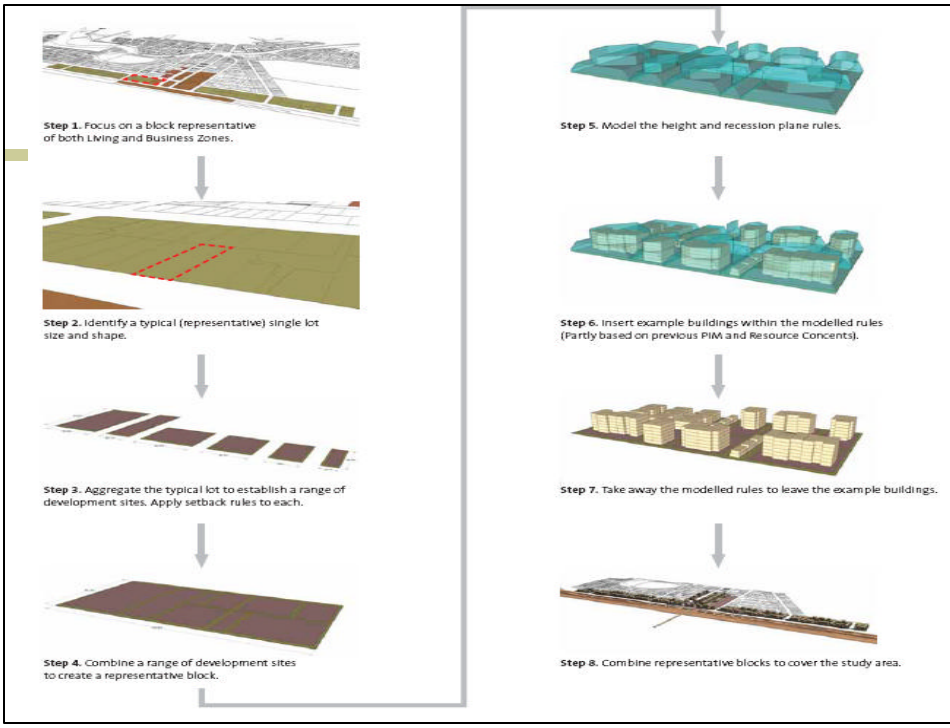
- PLANNING
- DESIGN
- CONSTRUCTION ISSUES

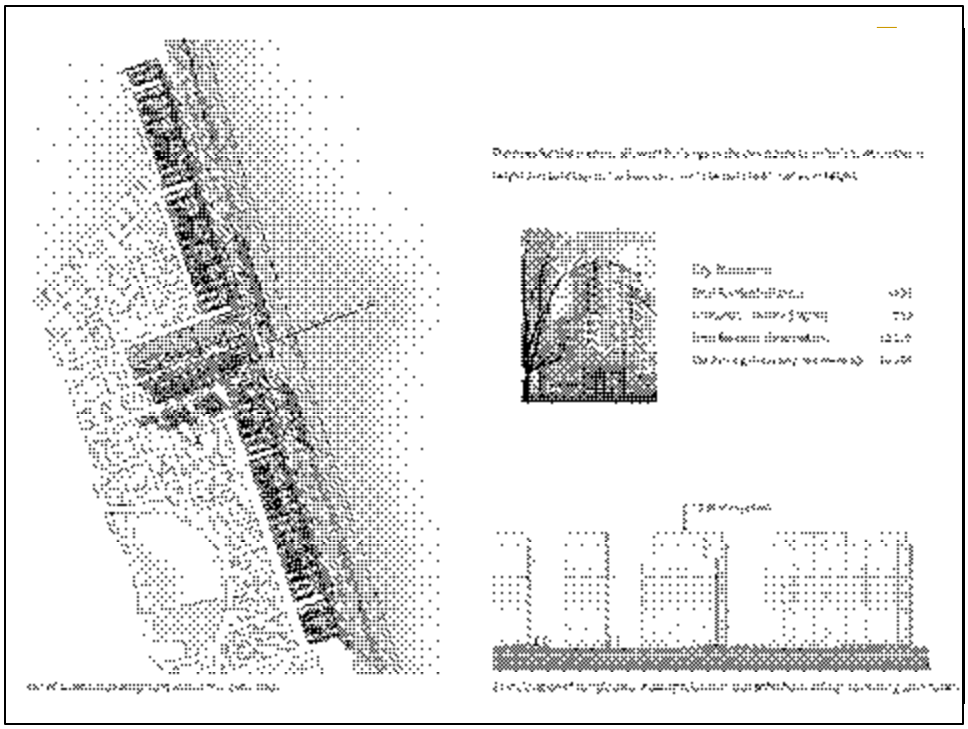
Development Planning

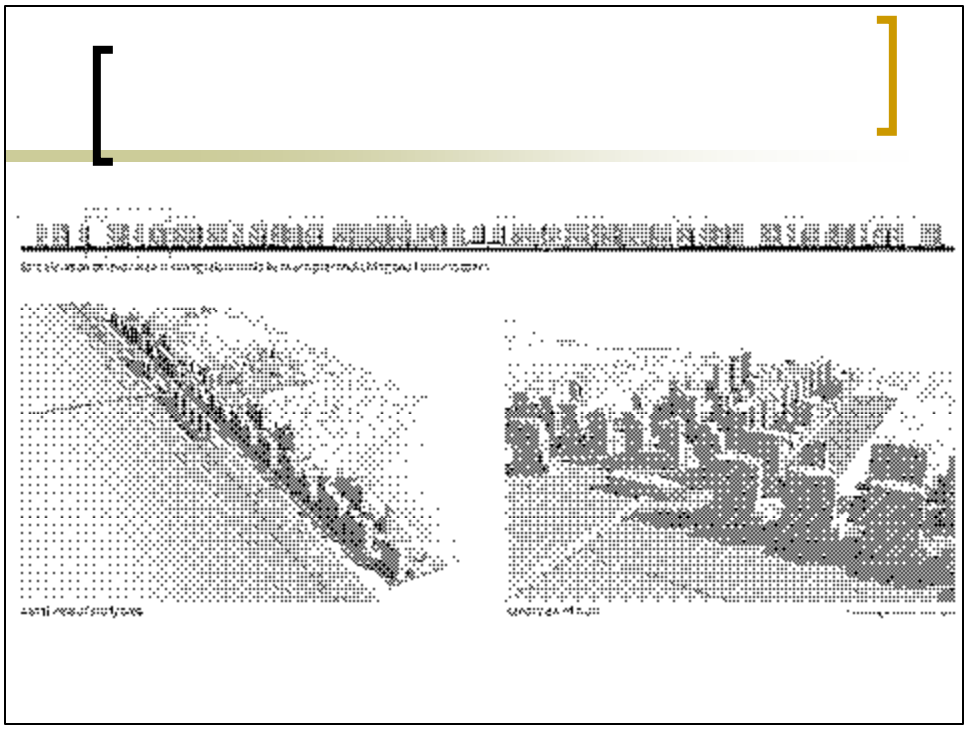
- Technical studies will look at:
  - Community views regarding changing development;
  - The visual/ landscape implications of a range of building heights and bulk;
  - Potential shading effects;
  - Potential wind tunnel effects;
  - Transport implications;
  - Geotechnical/ engineering and natural hazard issues;
  - Infrastructure capacity eg. water, sewer, electricity, drainage etc;
  - Capacity of community facilities eg. primary school, library, parks;
  - Economic implications;
  - Social effects.

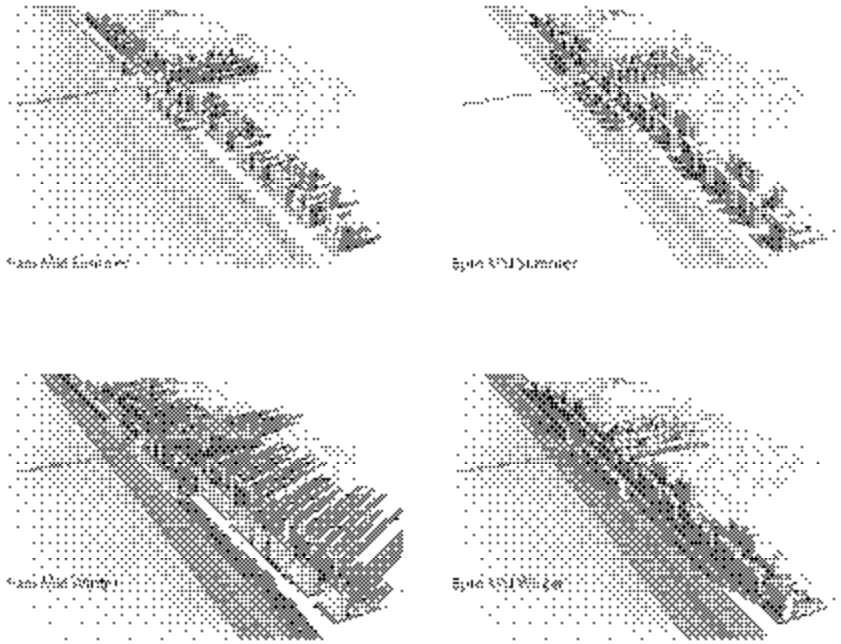
Legal Issues

- Feedback from the community, in combination with the technical reports, will be combined to produce a 'Section 32' report.
- Councilors will consider the S.32 report and decide whether or not the City Plan should be amended;
- If Council decides to amend the Plan, then the proposed changes are publicly notified so that anyone can make submissions on the proposed changes. Submitters have the opportunity to present their views at a public hearing;
- Having considered all the various views at the public hearing, the Council makes a decision on whether or not the City Plan should be amended;
- The decision of the Council is able to be appealed to the Environment Court by anyone who made a submission.









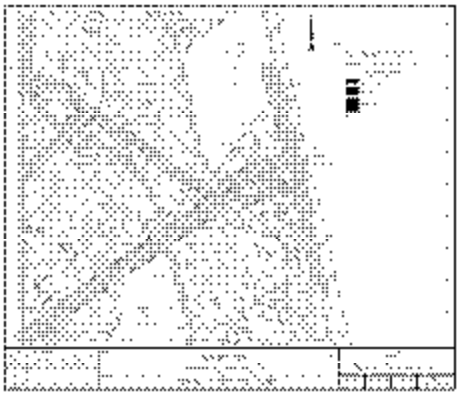
Natural Hazards & Engineering Issues

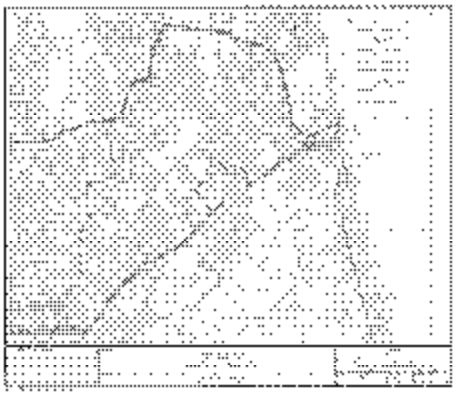
- Seismic Hazard/Liquefaction
  - ***Liquefaction***
  - ***Tsunamis***
  - ***Erosion***
- Climatic Hazards
  - ***Wind***
  - ***Flooding***
  - ***Snow Storms***
  - ***Climate Change***
- Structural System
- Wind Tunnel Studies
- Traffic Issues
- Fire Hazard
- Social Issues
- During Construction Requirements

Traffic issues

- Traffic generation surveys for local travel characteristics
- Traffic volumes for highest density development scenario
- Analysis of key intersections using potential future traffic volumes
- Maximum traffic volumes that can be catered for at key intersections

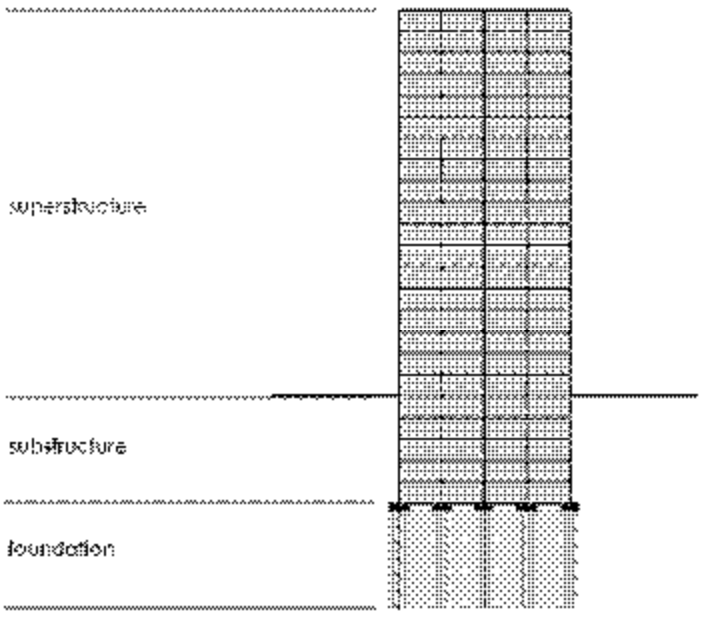
Traffic Design Studies

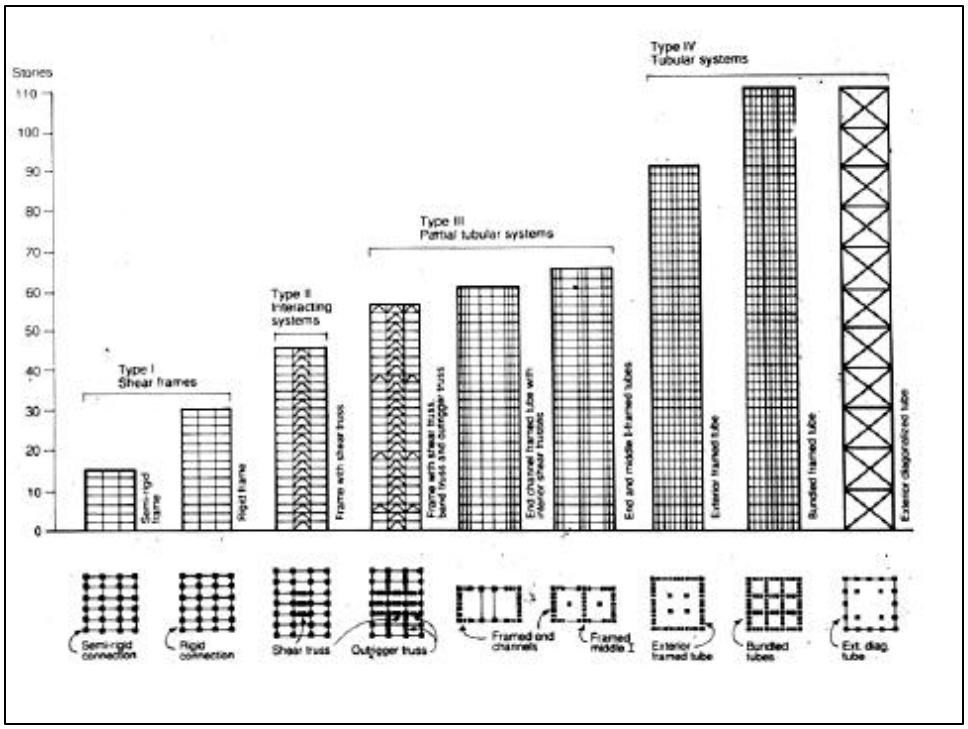




"Logic has its own inherent beauty. Logic is inevitably present in engineering's greatest achievements, and though it is true that towers have both an emotional and a rational aspect, if it were to be applied more rigorously to the design of the skyscraper, it would offer a fine chance to achieve a real sense of harmony between engineering and form."

- Chris Wise, "How to Design a Tower," 2001





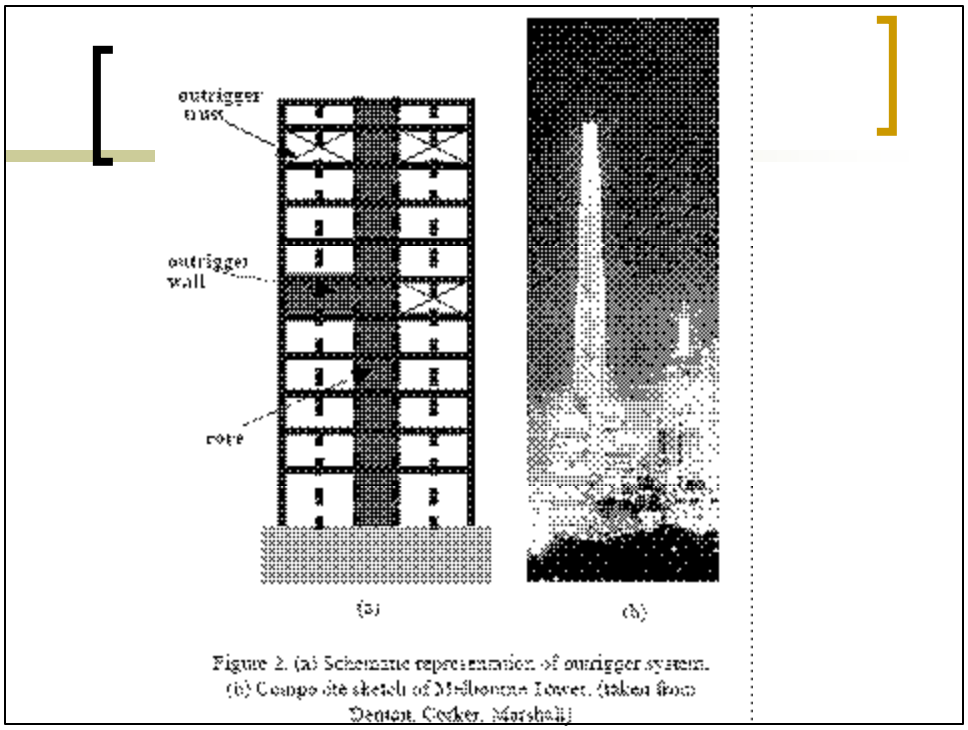
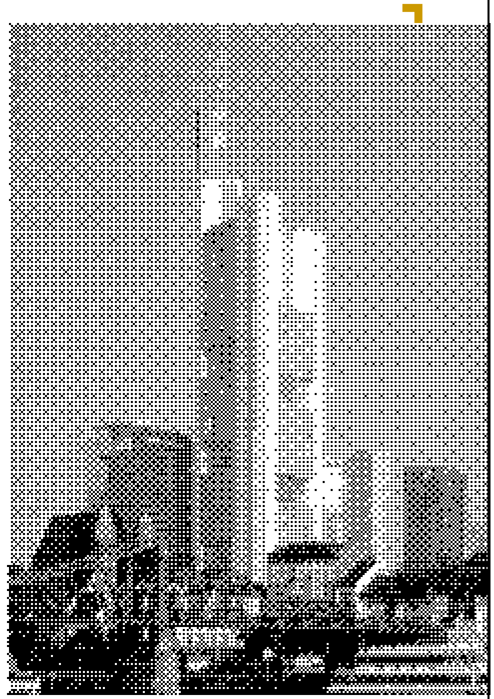
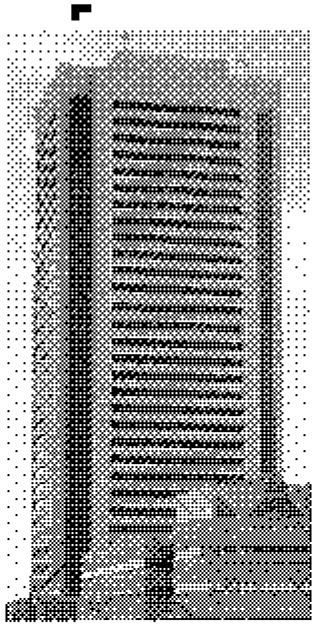


Figure 2. (a) Schematic representation of outrigger system. (b) Composite sketch of Melbourne Tower. (taken from Dennot, Cocker, Marshall)

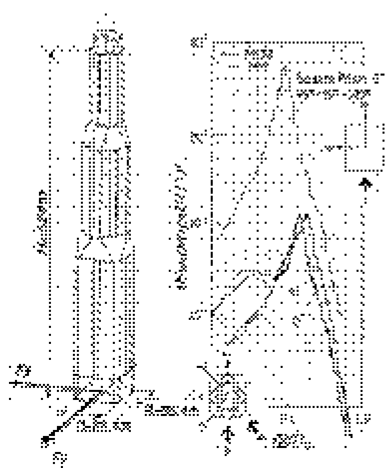
Super frame

- composite frame:
- building acts as vertical 'table' or bridge structure
- perimeter cores act as masts or 'legs'
  - mega-columns become program spaces
  - massive concrete super-walls
- body of structure = series of steel spans



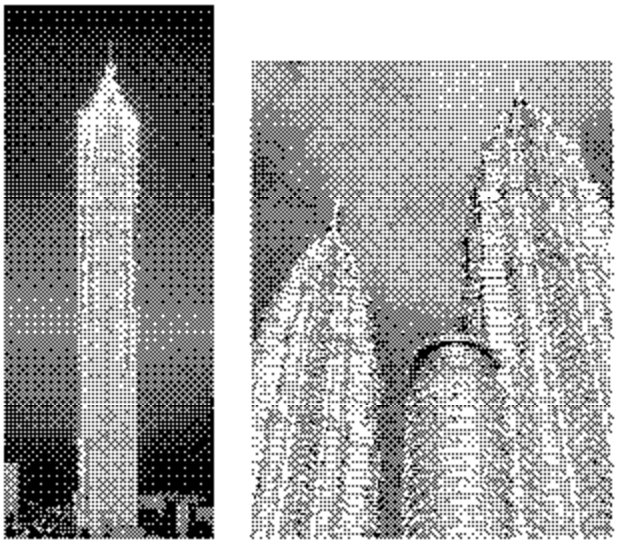


(a)



(b)

Figure 2: (a) MHI Yokohama Building (taken from *Mitsubishi Heavy Industries, Ltd.*) (b) Efficiency of changing sectional shape along vertical axis. (*taken from Simonds & Ellis 1995*)



(a) (b)

Figure 5: (a) Sketch of Jin Mao Building, (*taken from Skidmore, Owings, and Merrill, LLP*); (b) Photo of upper plan of Petronas Towers (*taken*

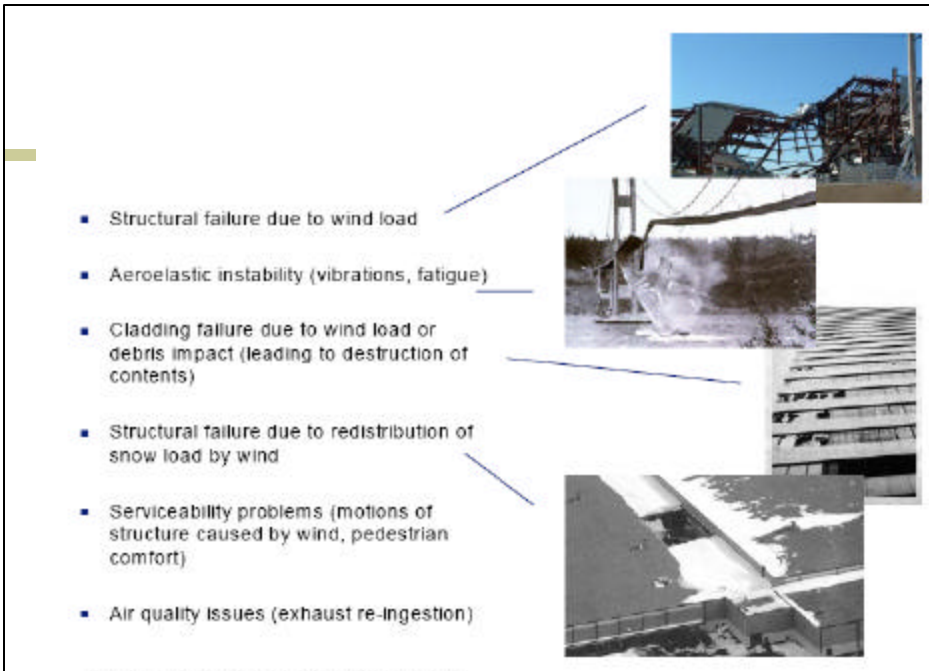


Figure 1: Types of Risk from Wind

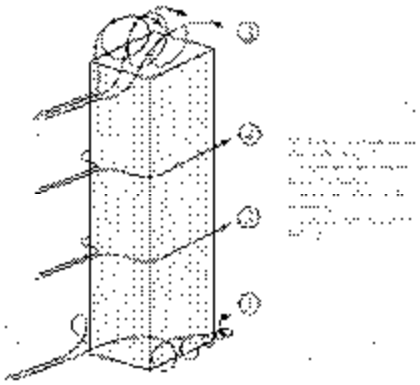
Wind Issues

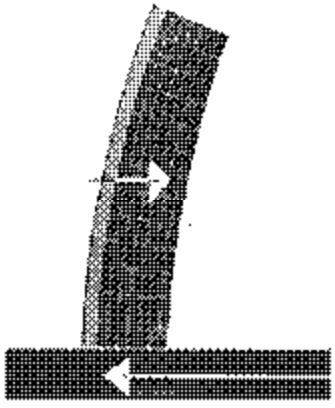
accelerating ground level wind around the corners of the building

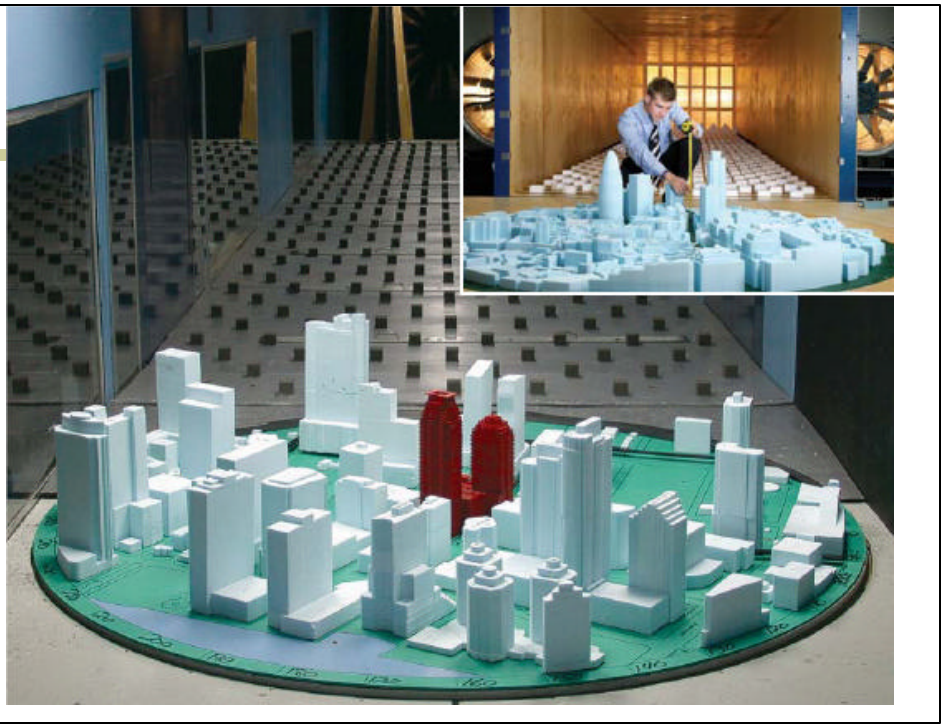
deflecting wind flows down to ground level

channelling flow between adjacent buildings

Different buildings can interact to create windy conditions.







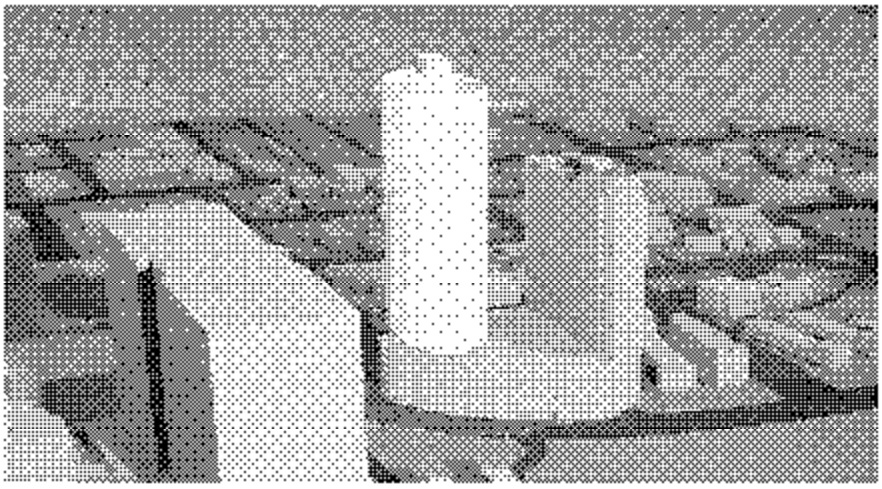


Figure 21: The oval building in the centre generated large torsional loads on the rectangular building to the right by partially shielding the dominant winds on its wide face. Fortunately it was tested with and without the oval building in place during a previous study and was designed to accommodate the torsional loads. How many buildings are not assessed in this manner?

Figure 8: Aeroelastic Model of Burj

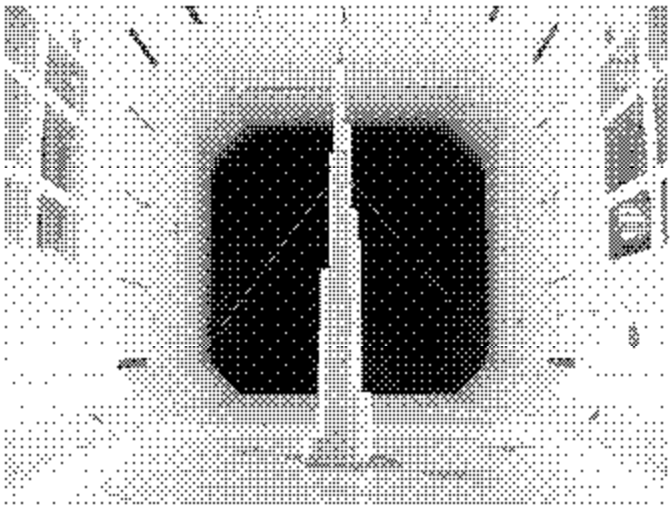
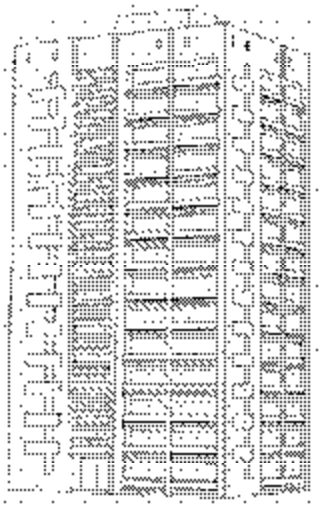
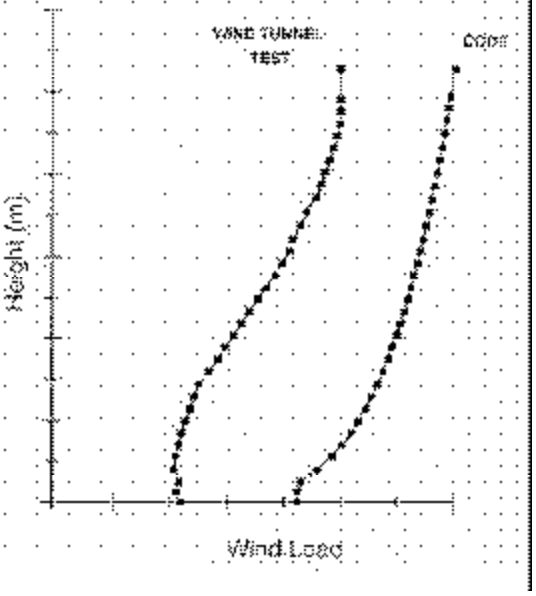
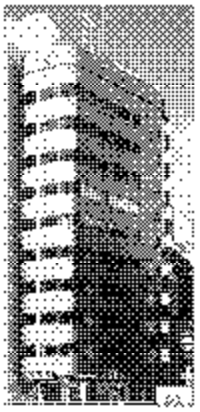


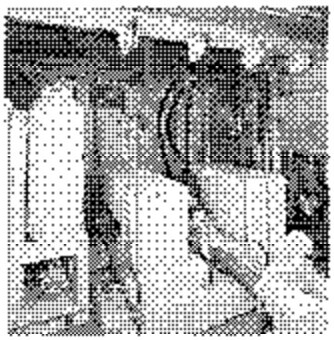
Figure 11: 1:15 Scale Model in NRC 9m x 9m Wind Tunnel, Ottawa

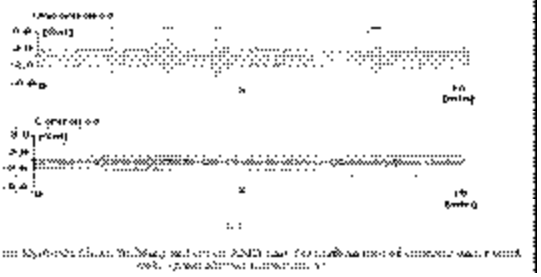
Structural Loads











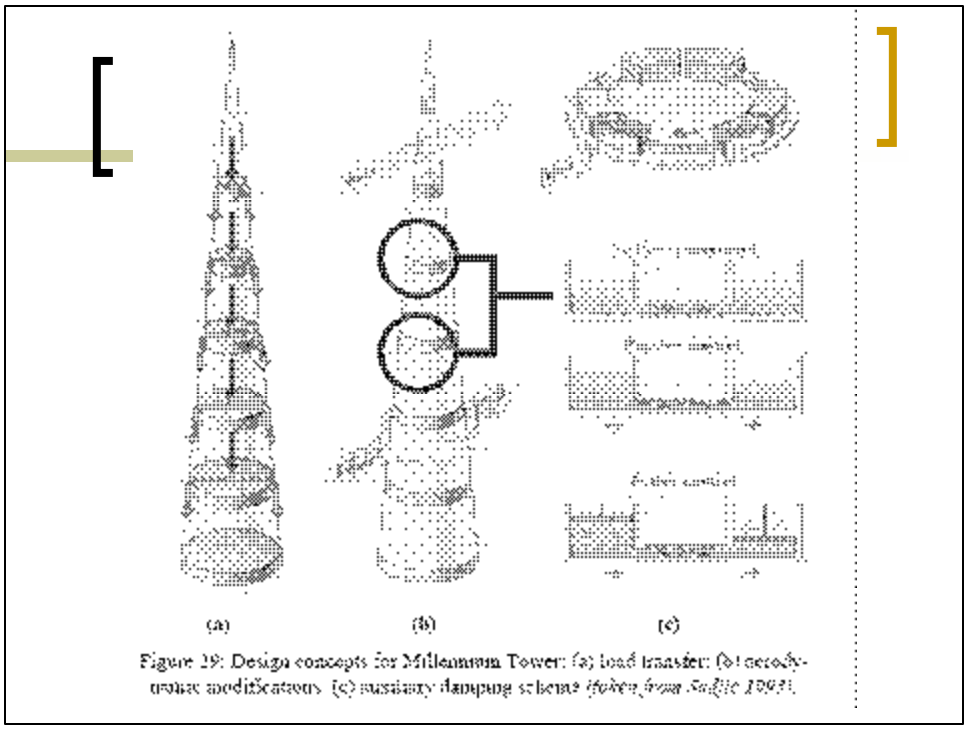
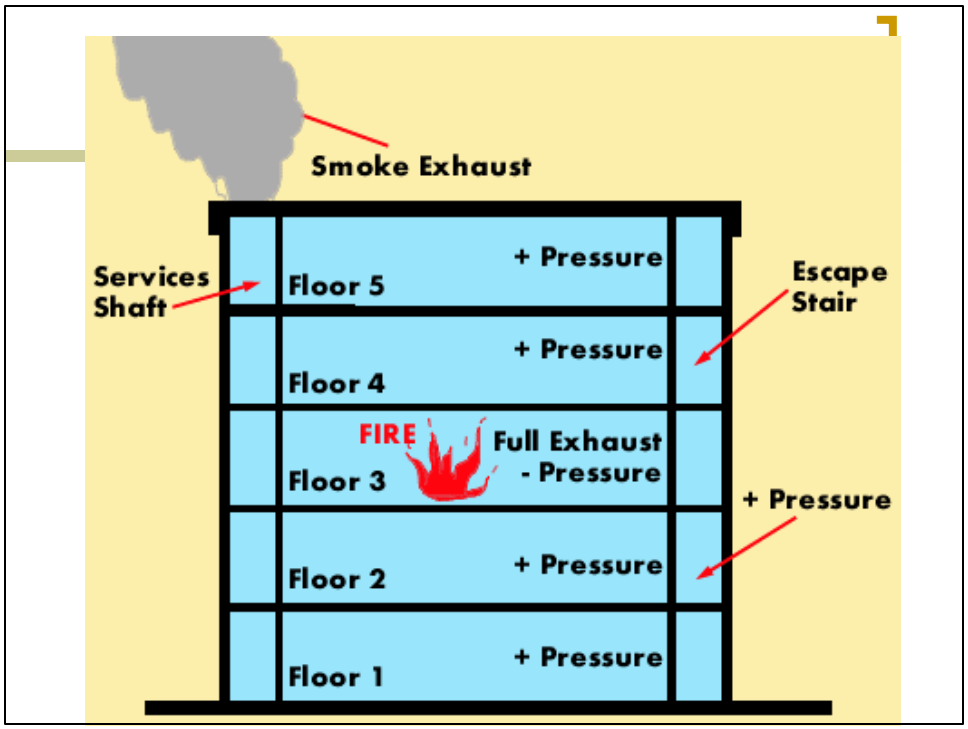


Figure 29: Design concepts for Millennium Tower: (a) load transfer; (b) aerodynamic modifications; (c) auxiliary damping scheme (*taken from Sadlic 1993*).



- Fire initiation and development
- Calculation of fire size
- Means of detection and suppression
- Smoke management
- Means of escape
- Fire fighting facilities and response
- Control of fire spread both within the building and to adjacent buildings
- Compartmentation
- Real performance of structures in fire
- Emergency light and power
- Materials and their response to fire – internal linings and finishes

Fire Safety

- Development of ductile standard details for extreme fire conditions
- Correlation of fire protection with fire performance so that appropriate levels are recommended in Building Codes.
- Documentation and agreement of non-linear analysis techniques.
- Development of fire protection that will avoid "pop-corn" effects for concrete elements and passive fire protection materials.
- Progressive collapse on a large scale is not well understood and needs to be better documented. Many buildings in the US are currently demolished using explosive and progressive collapse and could provide excellent opportunities for further investigation and research.

Construction Issues

- High Strength & Light Weight materials, memory alloys, HSC, Composites
- Special Tower Cranes
- High Pressure Concreting
- Special Skilled Work Force
- Project Procurement Skills
- Sub-contracting management
- Timeline Management
- Financial Management

Figure 9: Hoisting Car

Figure 10: Panel Suspended from Trolley Ready for Final Installation

Infrastructure

Stormwater

- Sufficient capacity within the Business zone portion of the study area to cater for increased density.
- The existing system would not cater for increased density in Living zone areas.
- New retention, treatment and piping systems would need to be installed once any change in residential density is known.

Potable water supply

- Upgrading of local pipes and pump stations would be necessary and would be designed to a scale to meet the specific development.

Waste water

- Upgrading of local pipes and pump stations would be necessary and would be designed to a scale to meet the specific development.

Electricity

- Electrical network capacity of the district substation is reasonably well placed to supply another 2000 households in the greater new city area.
- There is some spare capacity on smaller distribution cables but any large scale development would probably require additional cables at relatively low cost.

Telecommunications

- New connections would be arranged at the time that development occurs.

Infrastructure

Police services and the Fire service

- Both the police station and fire station may be branches of centralised services, there is capacity to call upon back up from other areas if necessary.

Religious facilities

- Generally people accept the need to travel to their selected religious facility according to their personal needs.
- A growth in residential density may encourage expansion of existing religious facilities or the establishment of new facilities to meet population demands.

Sports and recreational groups

- A wide variety of sports and recreational groups may require additional indoor and outdoor sports and social opportunities.

Open space / Reserves

- New Expansion needs to keep provision of reserves and open space, sports fields, play areas and the golf course.

Social Issues

- The Social Impact Assessment is focusing on the potential changes in the population of New City Development.
- We are examining what changes there could be in the size of the population and in the characteristics of the population.
- We are mainly relying on information gathered in the five-yearly Census of Population and Dwellings.
- To get an idea of what the potential future residents of the new developments might be like, we are looking at data for areas in which similar developments have occurred.
- We will then overlay the population characteristics of those areas onto New City and assess the differences created.